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IRRI'S RESEARCH ON EMERGING TECHNOLOGIES AND DEMAND FOR WOMEN'S LABOUR

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Efforts to develop new and more productive agricultural technology are in response to increasing food demands in Asia. Traditional technology, as practiced in Asian agriculture, possesses limited labor productivity and limited potential for increasing yields. New rice technology may encompass changes in any component of the traditional agricultural system: 1) new tools, 2) machinery, 3) production inputs, 4) agricultural practices, and 5) management of water and land resources. In changing how productive activities are carried out, new rice technologies will affect demand for women's labor and management skills. This paper presents a summary of the emerging technologies reports presented at IRRI's Women in Rice Farming Systems conference, held September 26-30, 1983. Acknowledgement is expressed to the contributors: V.G. Cordova, A.U. Khan, G.S. Khush, J.K. Ladha, J.A. Litsinger, K. Moody, P.A. Roger, A. Te, S.S. Virmani, and I. Watanabe. Discussion of implications for female labor and management activities reflects issues and problems raised during the conference.

New rice technologies have not exhibited the wide scale adoption as hoped. Continued use of traditional agricultural practices in many parts of Asia reflects the inappropriateness of many "new" agricultural technologies. Many regions lack the physical and socio-economic conditions most conducive for successful adoption of new agricultural technology. In less favorable areas, traditional technologies provide goods for a limited regional market and require simple skills and little cash inputs. Yet, increasing population and competition for limited resources demand greater agricultural productivity in marginal areas. New agricultural technology should not only increase yields but also raise labor productivity, that is, increase returns to agricultural labor.

Recognizing that farmers have not adopted technical recommendations, scientists are now researching technologies to address problems earlier developments did not answer. Specifically, technological research is addressing the bio-physical and economic constraints that have prevented adoption of new technology across variable physical and socio-economic environments. In marginal areas, appropriate technology holds greatest promise for women where it can raise labor productivity of poor farm households and increase productivity of marginal land.

Additionally, impact studies of new rice varieties suggest unequal benefit distribution. The new seed-fertilizer technology raises returns to both land and labor. Benefits from these increased returns are distributed according to the existing pattern of resource

distribution. The seed fertilizer technology itself contains no inherent bias towards impact distribution, but other technologies, such as direct seeding-herbicide use, have a specific bias towards the substitution of capital for labor. New technologies for specific activities have significant impact on labor and productivity. Technological research and development has often not been directed at those rice production tasks for which women are generally responsible. Within Asian rice farming, women contribute most of the labor in transplanting, harvesting, and weeding (Table 1). One exception to this pattern is Bangladesh, where women do not participate in field work but do almost all of the post harvest processing. Elsewhere, women's contribution to total rice cultivation labor is rarely less than a third of total labor input. Their contribution is highest at one-half in Nepal and India, and is roughly a third in southeast Asian countries. Their proportional contribution does not decline with development, as it is still 30 to 40% in Malaysia, Japan and South Korea.

Studies indicate that when technology is introduced, programs have tended to ignore rural women, even when they are traditionally responsible for the activity affected. Agricultural extension services are generally directed at men, who are perceived to be the managers of farm households. It is assumed that benefits and skills will inevitably accrue to women as members of the the farm household. Yet in Nepal, for example, women's traditional role in fertilizer decisions declined after extension programs provided subsidized credit to men for

use of chemical fertilizers (Pradhan 1983). While technology itself often contains no inherent bias towards benefit distribution, other factors influence the ultimate impact of technological change on the rural sector. The specific changes for each component and the nature of the extension system determine the differential social impact.

It is beyond the scope of this paper to discuss the implications of agricultural extension and gender differences in control of resources. IRRI's contribution lies in research and development of new technologies which consider bio-physical and socio-economic constraints previously ignored. Changes in objectives affect the targeted population and ultimately have implications for women's employment opportunities and decision making roles Thus, while continuing efforts to increase yields, technological research is also addressing problems of minimizing production costs and reducing yield losses. These advancements often require new management skills, and greater site-specific practices, both of which have potential for use of female labor and management skills.

IRRI's emerging technologies reports cover the following research areas: 1) improved rice varieties, 2) hybrid rice technology, 3) wet-seeded rice, 4) biological nitrogen fixation, 5) integrated pest management, and 6) mechanization. Specific technologies hold different implications for use of female labor and/or management skills. The following discussion presents an overview of emerging technologies being researched at IRRI.

1. Improved rice varieties

Early genetic breeding research was directed at increasing yields and, thus, raising food production. Initial development of short stature, non-photoperiod sensitive modern varieties produced higher yields. However, early IRRI varieties, such as IR 8, had problems of poor grain quality and susceptibility to insects and pests. Later varieties produced better appearance, higher milling recovery, and multiple resistance to major diseases and insects. New varieties, such as IR 28, IR 30, IR 36, and IR 50, combine multiple resistance with short maturing duration of 105-110 days. Widely accepted throughout Asia, the short duration varieties have facilitated crop intensification in many irrigated and favorable rainfed areas (Table 1).

Still, 50% of the rice area in south and southeast Asia is not irrigated. Thus, only traditional varieties are grown in these areas. Research now also must develop improved varieties for unfavorable environments, including rainfed lowland, deepwater, tidal wetland and upland areas. Our research priority is to develop plant type prototypes to test under specific unfavorable environments (Khush 1983).

Continued efforts to improve varieties for irrigated areas is a second research priority. Research continues to shorten rice growth duration. IRRI has developed breeding lines which mature in 95-100 days if planted on irrigated land with good water control. Shorter

growth duration enables greater cropping intensity and should produce a greater and more frequent demand for hired labor. Increased demand for labor generally occurs in those tasks, such as transplanting and harvesting, which traditionally have employed female labor. Increased cropping intensity can also shorten the time between harvests, thus shortening the "lean" seasonal period characteristic of traditional cropping patterns. This is especially critical for landless household dependent on hired wage labor for household subsistence.

Modern varieties have generally required more labor than traditional varieties, due to several factors. Recommended fertilizer use also encourages greater weed growth; thus more weeding is required. Increased yields also require more harvest and post-harvest labor. Barker and Herdt (forthcoming) review 20 village studies of labor use after MV adoption throughout Asia and conclude that labor use increased in 13 cases and remained constant in another 3 cases. Some of these findings are presented in Table 3, and they show gains in labor productivity as well as labor use. Increased labor is also generally reflected in women's tasks: intensification of crop establishment (transplanting in straight rows) and crop care (weeding and fertilizing), and harvesting and processing additional yield (Agarwal 1983). As increases in labor demand are principally for women's tasks, new varieties appear to have expanded their employment opportunities.

2. Hybrid rice technology

IRRI's hybrid rice technology research intends to develop hybrid rice varieties suitable to tropical conditions of south and southeast Asia. China is presently the only country in which hybrid rice is commercially grown. China's agricultural research efforts have expanded the hybrid rice production area to more than 5.3 million ha., comprising approximately 17% of the total rice area in the country. In China, hybrid rice produces 20% higher yields than modern varieties (Virmani and Te 1983).

China's hybrid rice varieties are not suited to the tropical conditions of south and southeast Asia. Virmani and Te (1983) report that IRRI-developed hybrids have produced superior yields of 14 to 34% on IRRI farm trials and 7 to 48% in collaborative field trials in Indonesia, India and South Korea. Virmani and Te also predict that perfection and adoption of seed technology in tropical conditions will require another five years of research and development.

Hybrid rice technology requires a new and complex set of management practices. Modern varieties are self-pollinating, and farmers may use harvested rice as seed in successive plantings. In contrast, hybrid rice requires specialized seed production in two main stages: 1) multiplication of male sterile seeds and 2) the production of hybrid seeds. The genetic cross of these two parent varieties produces the higher yields, the result of the hybrid vigor phenomenon. Farmers must purchase seed each crop season in order to sustain high yields.

Hybrid rice technology thus requires specialized seed production. Hybrid seed production involves crossing a male sterile line with a male parent, called the restorer, which then produces seed which is not sterile. Seed production requires labor intensive and complex techniques to ensure production of pure hybrid seeds. Chinese farmers physically isolate fields to prevent contamination of the male sterile seed. They also clip the flag leaves of the male sterile plant, ensuring exposure of the panicles, and often they manually drag a rope across the field during flowering to ensure cross-pollination. Additional labor and material inputs increase hybrid seed's cost. This discourages high seeding rates, as in direct seeding. Hybrid rice technology necessitates transplanting to minimize seed costs. Potential impact on female hired labor would be to increase demand for labor. The labor intensive seed production and higher yields could provide employment opportunities for women in households dependent on hired labor.

3. Wet-seeded rice

Wet-seeding is characterized by sowing pre-germinated seed onto puddled soil. This seeding method is increasing in importance in some southeast Asian countries, such as Malaysia, Thailand, and the Philippines. Wet seeding is not a new method of crop establishment and had been traditionally employed in many wetland conditions in the Philippines, Sri Lanka, and Thailand. Moody and Cordova (1983) note that a shift to transplanting was often a response to increasing problems with weeds.

As herbicide became more available and transplanting labor costs increase, many farmers are adopting wet-seeding methods. Direct-seeded rice require heavier herbicide use. Broadcast, direct-seeded rice precludes handweeding, characteristic of transplanted rice, and chemical herbicides must be used. In situations where labor costs for transplanting and weeding have increased, farmers may find chemical herbicide more economical.

Studies have also indicated that farmer use of wet seeding may reflect local bio-physical conditions (Mandac, et. al. 1982). Specifically, study of rainfed farming in Bicol province, Philippines, suggests that farmers decide to wet seed according to the water status of the field, the availability of seedlings, and the expectations of possible flooding. Adoption of the wet-seeding method significantly reduces labor time required for crop production. The most significant labor reduction occurs in transplanting, the activity with a high rate of hired female labor. Further research is needed to identify specific conditions within which farmers do adopt wet seeding methods before the implications for hired female labor can be assessed.

As Mandac's data suggests, it may be possible that wet-seeding methods are appropriate to specific bio-physical conditions. In some cases, wet-seeding may provide more secure and higher yields than can be obtained with transplanting.

Additionally, one must separate potential benefits and costs between farm and landless households. As hired labor costs increase,

the small farm household may minimize its costs by shifting to wet seeding. Indirectly, the potential impact for women in farm households may be positive, while the impact is negative for women dependent on hired labor for income. Adoption of wet-seeding practices may also be the result of decreases in availability of hired labor. Studies of the conditions and impact of technical change need to assess the female labor force participation within the whole system of production.

4. Biological nitrogen fixation

Modern varieties require heavy nitrogen fertilizer application to sustain high yields. In some Asian countries, government subsidization has reduced farmer expenses and thus encouraged greater use of chemical fertilizer. In general, farmers either do not apply fertilizer or apply fertilizer at much lower than recommended economic levels to achieve maximum yields. Some factors identified point to problems in availability and higher cost of chemical fertilizers.

Use of inorganic nitrogen fertilizer requires high cash inputs. IRRI's research on biological nitrogen fixation intends to develop less expensive methods of increasing soil nitrogen availability. Subsistence and small commercial rice farmers can benefit from modern variety adoption only if they can afford the required increase in expenditures for inputs.

In most paddy fields, a substantial portion of applied nitrogen is lost by leaching, denitrification, and ammonia volatilization.

The complexity of water and soil environment in wetland rice soils ensures a high potential for biological nitrogen fixation, and thus, reducing nitrogen loss. This complex ecosystem enables growth of all major groups of nitrogen fixing organisms: 1) heterotrophic bacteria, 2) phototrophic blue-green algae, and 3) symbiotic blue-green algae, associated with azolla (Ladha, Watanabe, and Roger 1983). Experiments at IRRI indicate that these organisms can fix an amount of nitrogen in the soil, making it available for the rice plant's uptake.

Research and development of alternative fertilizer sources holds possible implications for women in small farm households. Adoption of low cost methods provides greatest benefits to those small farm households who cannot afford more expensive commercial fertilizers. Additionally, production and incorporation of the microorganisms requires extensive labor. While providing the benefits of low-cost higher yields to the household, use of labor intensive production could require greater use of family and hired labor.

This research is still at the initial stage. As energy costs rise and fuel supplies become more uncertain in developing countries, chemical N fertilizer prices may increase significantly, thus making use of biological nitrogen fertilizer more attractive. Several qualifications should be noted. Use of nitrogen fixing microorganisms is extremely labor intensive. Farmers may prefer to purchase fertilizer because of relative ease of management and incorporation. Additionally, further research is needed to understand better the specific soil conditions most conducive to specific organisms and the

nature of the rice plant's response to increased soil nitrogen. These data can ensure successful farmer adoption within their field conditions.

5. Integrated pest management

Adoption of modern varieties has produced the intensification of rice production needed to increase food production. These conditions have also encouraged a general increase in pests and diseases and the evolutionary development of insect and disease biotypes resistant to conventional chemical pesticides. Irrigation systems providing a constant water source allow year-round production. Modern varieties have often been more susceptible to pest damage than traditional varieties. Heavy fertilizer use can often increase the rice plant's susceptibility to pest and insect attack.

Introduction of modern pesticides was intended to alleviate the pest problems encouraged by wide scale adoption of modern varieties. Modern pesticide use has not resolved these problems due to a number of factors. The field and regional ecological conditions under modern varieties comprise a dynamic system too complex to be controlled by chemical pesticides. Misuse of pesticides, both by overuse and spraying at low dose concentrations, has often either created a pest resurgence or selected for resistant pest, thus creating a greater problem in the long run. Additionally, increasing number of pests and resistant pests increase farmer pesticide costs.

Scientists have recognized chemical pesticide's failure to resolve major pest problems in farmers' fields. Integrated pest management

incorporates management instead of eradication concepts. The goal is to maintain pest populations below the levels of significant economic damage through adoption of management practices which do not encourage later major pest outbreaks (Litsinger 1983). Pesticide is applied only when it is economical for the farmer to do so. Integrated pest management reduces yield losses and production costs.

Rejecting calendar spraying practices, integrated pest management requires greater management skills and situation specific decisions by farmers. Unlike much of IRRI's research now, integrated pest management contains significant farmer extension and training components. Aimed at reducing pesticide expenses and managing pest levels over time and space, integrated pest management requires extensive farmer participation for development and maintenance of successful management "systems."

IRRI's research on pest management strategies has focused on long term extension and farmer training to identify pests and manage pest levels in farmers' fields. Currently, efforts have been directed through farmer training course and follow-up session in communities. No special effort is directed at including women, but their decision making role in household purchases could be used to encourage economic and judicious pesticide use. Additionally, in the Philippines, female extension agents have had a major role in teaching farmers about integrated pest management.

6. Mechanization

IRRI's mechanization and development intends to provide small-scale appropriate machinery for the small Asian farmer. Mechanization

of production activities can increase productivity, reduce yield loss, and also displace labor. The impact and potential benefits from mechanization are distributed differently between two major groups, small farm and landless households.

In regions with a large landless population, labor-using technical change is most desirable. The proportion of rural landless households dependent on agricultural work is estimated at 27% for India, 41% for Java, and roughly 12% for the Philippines and Sri Lanka (Barker and Herdt, forthcoming). Despite high population densities, studies have indicated increases in labor shortages during land preparation, transplanting, and harvesting periods in some areas. In those situations where increasing labor shortages are evident, introduction of small scale mechanization can facilitate the farmer's production activities.

Private financial support for research and development is primarily directed towards labor-saving technology, often too expensive for small farmers. Application of government subsidies can encourage adoption of inappropriate machinery. This can distort the mechanics of the existing economic system and the needs of both small farmers and hired labor. IRRI established the Small Farm Machinery Development Program in 1967. IRRI's research intends to develop small-scale machinery appropriate to the needs of small rice farmers (i.e. those farming 2-10 ha.). Market-oriented, the program provides machinery design for simple, low-cost agricultural equipment to be locally manufactured.

a. Axial flow thresher. The development of the axial flow thresher was in response to small farmers' need for more appropriate machinery. Previously, farmers used manual threshing methods or contracted with large thresher operators. Large, McCormick type threshers were commonly used in major rice-producing areas, such as Central Luzon, Philippines. Due to the limited number of contract threshers, farmers often could not thresh at the most appropriate time and lost a substantial percentage of their crop to spoilage, inclement weather, rodents and insects (Khan 1983).

IRRI intended to develop machines that could be locally produced, were well suited for threshing wet paddy, and did not significantly displace labor. Several research and development stages were required. Research on a large tractor P.T.O. operated axial flow thresher was abandoned in response to concerns about excessive labor displacement (Khan 1983).

The current model is a small engine driven lightweight throw-in type axial flow thresher. The first prototype was tested and improved in different parts of the Philippines during 1972-1973, both by IRRI and after release, by private manufacturers. After threshing 100 tons of paddy, each machine would be broken down and inspected for structural weaknesses (Khan 1983). Currently, these machines have been widely adopted throughout Central Luzon and Laguna, two major rice-producing areas in the Philippines.

Research efforts have also produced a smaller portable version of the IRRI axial flow thresher. The lighter version, carried by four

operators, enables in field threshing in less accessible areas, eliminating transport costs and yield loss. The purpose of IRRI's research in this area is to develop small-scale machinery appropriate to the needs of 2 to 10 ha. Asian rice farmers.

b. Deep placement fertilizer applicators. Studies at IRRI and elsewhere have indicated that a high percentage of applied fertilizer nitrogen is lost in wet paddy soils. IRRI's biological nitrogen fixation research focuses on the chemical dynamics of the soil environment and how to alter this environment to make more soil nitrogen available to the rice plant. Research has also indicated that the mechanics of fertilizer placement, often surface broadcast, also contribute to high fertilizer loss rate. IRRI's research demonstrates the potential for doubling fertilizer use efficiency by placing fertilizer in the reduced soil layer at depths ranging from 5 to 15 cm. (Khan 1983). Placement can be done manually, but machine application is often more reliable, more productive, and much easier.

Initially, most machines developed in Japan, China, and at IRRI, were developed to deep place prilled urea. In Asian rice production, prilled urea is the most popular fertilizer material; generally, it is broadcast after transplanting. Erratic performance of these machines during IRRI's testing suggested that prilled urea might not be the best fertilizer form. Thus, IRRI also developed urea briquets and urea supergranules in an effort to find a form more suitable for deep placement.

Currently, five new applicators are being tested at IRRI for fertilizer use efficiency and effectiveness. These applicators, two for prilled urea, one for both prilled and forestry grade urea, and two for urea super granules are designed to reduce nitrogen loss in soils flooded at application time. Reducing fertilizer loss requires a machine which places the fertilizer in the soil and then recovers the fertilizer to minimize fertilizer contact with water (Khan 1983).

Recent field trials on the two prilled urea deep placement applicators, the auger and the oscillating plunger, resulted in an even lower nitrogen loss to floodwater than hand placement of urea super granules (Khan 1983). Further tests are now being conducted by IRRI Agronomy and Agricultural Engineering departments and by the Philippine Ministry of Agriculture. IRRI hopes to release the designs to local manufacturers by 1984.

Conclusion

Emerging technologies will have an impact on the demand for women's labor and management skills in the future. The pessimism cited above concerning the future capacity of rice agriculture to absorb labor may be premature. There are three types of yield-increasing, labor-using rice technologies under development that appear particularly promising: newer MVs, hybrid rice, and better fertilizer efficiency. First, the latest MV releases are super-short duration and will allow further increases in cropping intensity.

Other MVs are being developed to provide higher yields in less favorable environments and these could raise yields in a much larger part of Asia. Another source of higher yields is use of hybrid seed. Both traditional and modern varieties are pure varieties, and farmers can use seed from their own production. Hybrid seed is the result of cross-pollination between two varieties and new seed must be prdouced every year. Preliminary evidence indicates that use of hybrids could increase yields by 20 to 30 percent. A third yield-increasing technology is the use of simple deepl-placement machines for fertilizer application. These can double the efficiency of inorganic fertilizer through reducing the loss of nitrogen in water. Thus yields can be increased without any increase in fertilizer cost. All of these technologies are likely to benefit women in labor abundant countries through raising demand for labor.

Another labor-using technology is the use of bio-fertilizers, such as azolla, to fix nitrogen in the soil. Use of this technology substitutes labor for purchased inorganic fertilizer. Farm household women can benefit from this substitution where the opportunity cost of their labor is less than the fertilizer cost.

There is additional potential for diversification of women's employment opportunities through utilization of rice by-products. Rice straw used for animal feed can be fortified with urea and molasses for intensification of livestock production. Alternatively, rice straw can be used for biogas generation or paper production. Rice bran can be processed to provide edible oil and the de-fatted

bran can be fed to animals. Rice hulls can be made into bricks or burned for energy.

Any changes in crop establishment will clearly affect women as they are responsible for transplanting throughout Asia. Farmers in many parts of Asia traditionally direct-seeded their fields and substantial portions of the rice crop are still direct seeded in Thailand and Sri Lanka. A shift to transplanting or intensification through transplanting in straight rows to allow easier weeding is sometimes considered part of the Green Revolution package. Rising labor costs in some countries has led to adoption of direct seeding and herbicides to replace transplanting and weeding. The suitability of this technology where transplanters are hired female labor requires study. Price policies with respect to herbicides should be carefully considered in order not to encourage premature adoption. This technology may be most appropriate in areas where crop establishment and weeding are carried out by female household labor or where it can allow double-cropping by improving turn around time.

The most common types of mechanization will nto affect women directly. Women do not land preparation and little threshing in most Asian countries. Thus the adoption of tractors and threshers will not displace their labor. The increase in marketed surplus with growth in supply and urbanization has led to machine milling of rice in almost all Asian countries. In Nepal and Bangladesh, hand pounding of rice is still common, and thus a shift to machine processing would reduce demand for women's labor there.

Finally, more complex strategies to control rice pests will require the management skills of women in farm households. Integrated pest management is a package of cultural techniques, including the use of pesticide only in response to monitored pest levels. This technology is "management-using", as it requires greater understanding of the pest life-cycle in order to make complex decisions about pest control. Women's involvement in crop care suggests that they are the natural target group for training.

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EMERGING TECHNOLOGIES PAPERS PRESENTED AT CONFERENCE

Khan, Amir U. Two examples of emerging mechanization technologies at IRRI.

Khush, Gurdev S. Improved rice varieties in retrospect and prospect.

Ladha, J.K., I. Watanabe and P.A. Roger. Biological nitrogen fixation in wetland rice.

Litsinger, James A. Integrated pest management for rice in Asia.

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Table 1. Women's Participation in Rice Cultivation

Country	Seed Selection	Seed-bed	Land Prep	Trans-Planting	Crop Care: Weeding	Crop Care: Fertilizing	Crop Care: Insect & others	Harvesting	Threshing	Other Post Harvest	Marketing	Total
Nepal (Hill Systems)	X		0	64	72			52				34
India												
Andhra Pradesh			7	78	73	8	3	63	25			48
Tamil Nadu			0	69	85	39	8	64	41			55
Sri Lanka (Kandy)												
Irrigated			0	100	80	0	0	49		46		n.a.
Rainfed			0	91	80	0	0	37		67		n.a.
Bangladesh	X									X		
Thailand	X		16	29		33		73			61	n.a.
Malaysia	X	19	6	55	27	19		46	24	76	15	37
Indonesia (East Java)				X	X			X				35
Philippines (Central Luzon)			0	45	7			15				29
China		X		X		X		X				33*
Korea	33	27	2	48	23	12	24	34	34	43		36
Japan												40

Percent of total labor in each activity, where available.
X indicates that women are involved in the activity.

*Total farm labor in southern region.

Sources:
- Nepal - Pradhan (CP1983)
- India - Agarwal (CP1983)
- Sri Lanka - de Alwis (CP1983)
- Bangladesh - Abdullah & Zeidenstein (1983); Aziz (CP1983)
- Thailand - Chandratat (CP1983)
- Malaysia - Yap (1981)
- Indonesia - Collier (1982); Sajogyo (CP1983)
- Philippines - Sison, et.al. (CP1983)
- China - Croll (1979); Xue-bin (CP1983)
- Korea - Lee (CP1983)
- Japan - Yoshida (CP1983)

Table 2. Levels of irrigation, modern cultivars, and fertilizer used on rice in Asia, 1960s and 1970s.[a]

Location	1965-69			1975-79		
	Irrigation (% area)	Modern cultivars (% area)	Fertilizer[b] on rice (kg/ha)	Irrigation (% area)	Modern cultivars (% area)	Fertilizer[b] on rice (kg/ha)
South Asia						
India	38	7	13	40	37	40
Pakistan	100	10	13	100	46	43
Bangladesh	7	2	3	12	16	8
Sri Lanka	61	1[c]	36	66	55[c]	67
Southeast Asia						
Malaysia	65	3[c]	57	67	18[c]	69
Thailand	28	0	6	24	10	11
Philippines	40	22	14	42	70	36
Indonesia	65	3	11	70	35	41
Burma	15	1	3	17	12[c]	8
East Asia						
Japan	100	100	286	100	100	340
Taiwan, China	100	100	218	100	100[d]	246
Korea, Rep. of	84	0	143	92	51[d]	215
China	89	16	24	89	66	49

[a]Sources: Modern cultivars data from Herdt and Capule, 1983.
Fertilizer and irrigation data from Palacpac 1982.

[b]In nutrients (N + P + K); chemical sources only.

[c]Narrow definition of modern cultivars.

[d]% in indica-japonica crosses.

[e]Includes all provinces except Taiwan; data are assumptions as spelled out re Barker and Herdt (n.d.)

Table 3. Increase in labor, labor productivity and hired labor use with MV adoption, selected locations in Asia.

	Labor use ratio MV/TV (days/ha)	Rice/Labor ratio MV/TV (kg/day)	Hired labor ratio MV/TV (days/ha)
Indonesia			
West Java	1.6	1.2	1.4
Central Java	0.8	1.6	1.0
East Java	1.1	1.2	n.a.
Bangladesh	1.4	1.1	1.6
Philippines	1.2	1.2	1.7
Thailand	1.4	0.9	n.a.
S. Korea	1.1	1.2	n.a.
Sri Lanka	1.3	1.2	n.a.
India			
W. Godavari	0.9	n.a.	n.a.
Ferozepur	1.0	n.a.	n.a.
Kanpur	1.2	n.a.	n.a.
Palamau	1.7	n.a.	n.a.

Source: Barker and Herdt, forthcoming.

Table 4. Index of real wages of agricultural laborers in selected Asian countries (1965 = 100).

	Japan		South Korea		Sri Lanka		Malaysia	Philippines	India	Bangladesh
	Index	Ratio Female/Male[a]	Index	Ratio Female/Male	Index	Ratio Female/Male				
1965	100	0.80	100	0.74	100	0.82	-	100	100	-
1966	104	0.81	104	0.80	99	0.83	100	101	104	-
1967	111	0.82	112	0.82	98	0.84	95	102	103	-
1968	125	0.83	126	0.76	107	0.82	97	93	102	100
1969	132	0.84	136	0.68	100	0.82	100	84	113	99
1970	138	0.81	147	0.68	96	0.81	98	79	117	93
1971	179	0.78	155	0.68	96	0.97	93	78	86	75
1972	162	0.79	161	0.69	110	0.71	91	-	107	70
1973	170	0.79	171	0.70	93	0.91	89	-	92	67
1974	178	0.79	178	0.70	105	0.76	100	70	56	70
1975	197	0.79	182	0.71	122	0.78	90	-	84	70
1976	191	0.79	205	0.71	134	0.77	102	-	94	68
1977	195	0.78	230	0.72	146	0.77	102	-	89	70
1978	201	-	290	-		-	107	-	90	74
1979	202	-	372	-		-	119	-	90	-

[a]Ratio of female to male farm wage.

Source: Barker and Herdt (forthcoming) and World Rice Statistics, 1984.

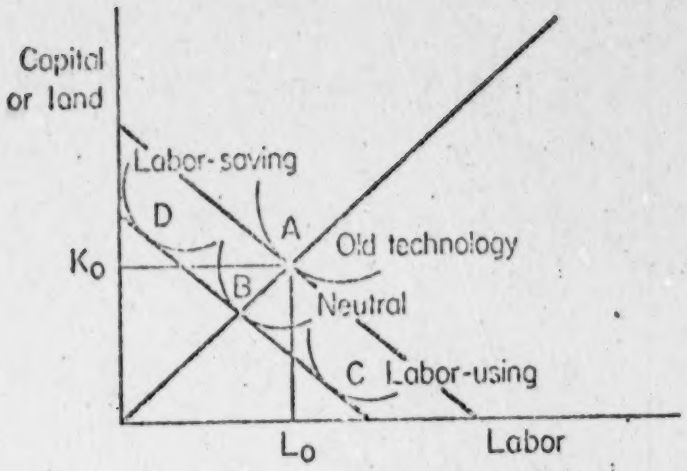

Figure 1. Technical change and factor proportions.

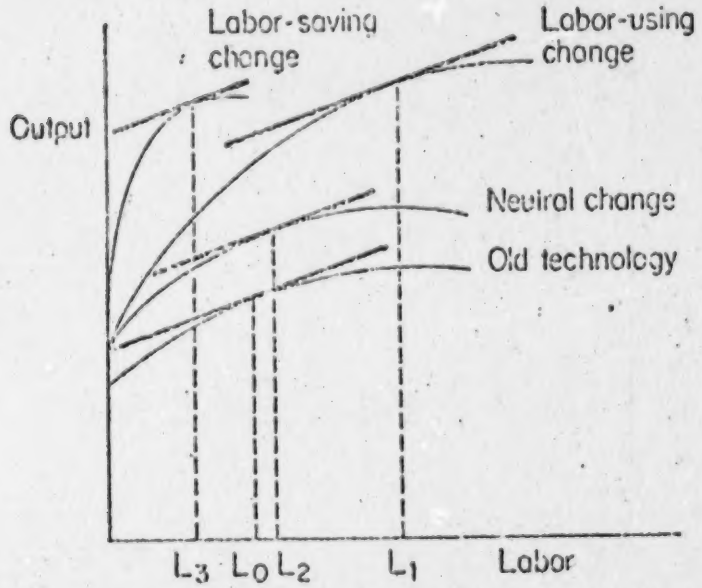

Figure 2. Technical change and labor use.

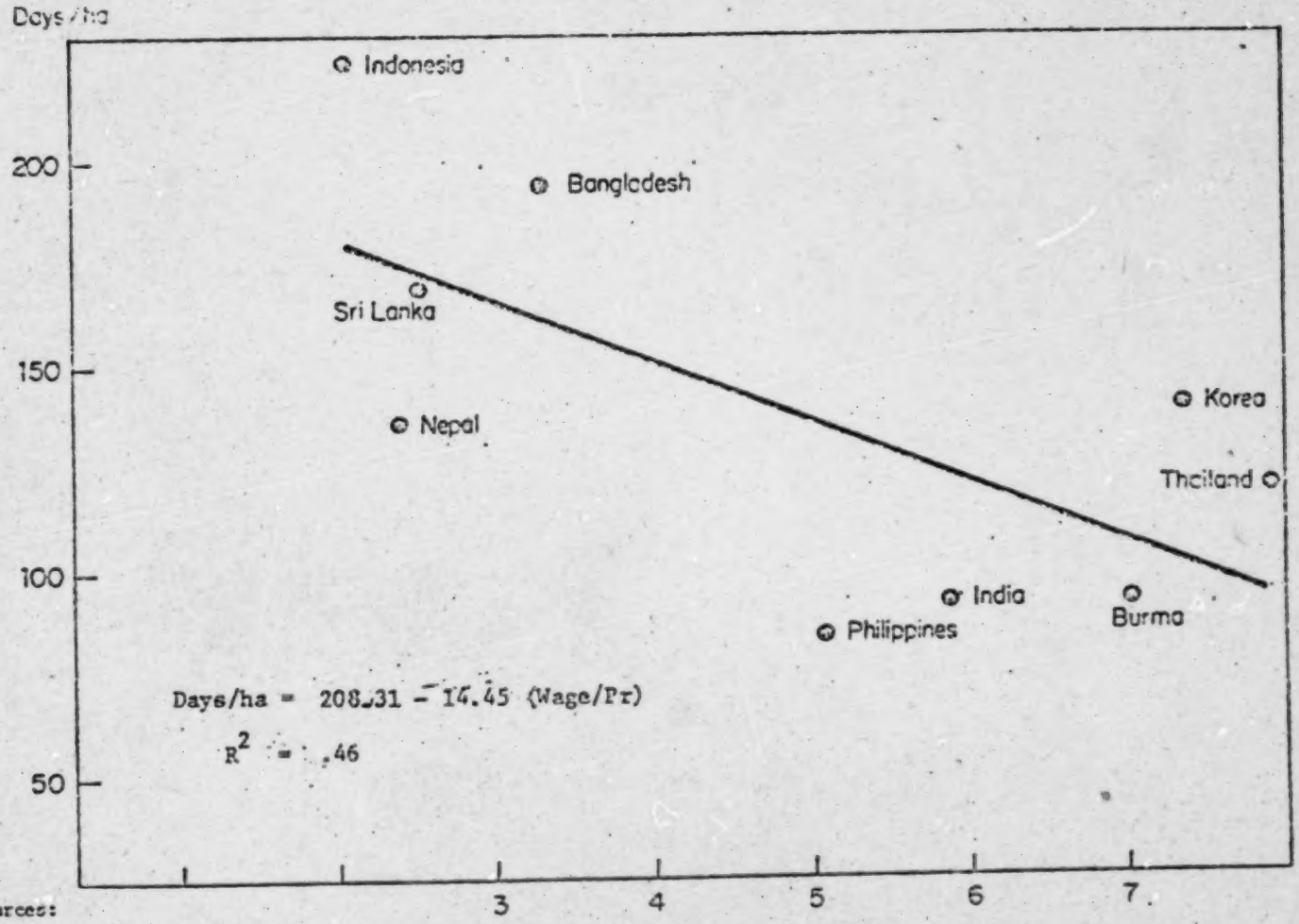

Figure 3

Sources:

.Data on days/ha:

Thailand, South Korea, Bangladesh, Sri Lanka, Indonesia - Barker and Herdt (forthcoming)

Burma - Paris, T. et.al., 1982.

Nepal - Karki, B.B. 1979.

Philippines- IRRI-Central Luzon data for 1979.

India - Indian Agricultural Statistics, Annual Report 1976-77.

Data on wage/rice price:

Thailand, South Korea, Bangladesh, Sri Lanka, Indonesia, Nepal, Burma - Barker and Herdt (forthcoming)

Philippines - IRRI-Central Luzon data for 1979.

India - Agricultural Situation in India for 1971-72.